JC03 Rec'd PCT/PTO 11 JAN 2002

FORM PTO-1390 (Rev. 11-2000) U.S. DEPARTMENT OF COMMERCE ATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
53550.41

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
10/030827

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/NO00/00236	11 July 2000	12 July 1999

TITLE OF INVENTION : Methods and Devices for Measuring Interface Levels between Fluids and Uses Thereof

APPLICANT(S) FOR DO/EO/US
Erling Hammer

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☐ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached herewith (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2))
   a. is attached hereto.
   b. X has been previously submitted under 35 U.S.C. 154(d)(4).
7. X Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☒ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (unexecuted)
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A **FIRST** preliminary amendment.
14. ☐ A **SECOND or SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 15(d)(4).
20. ☐ Other items or information:

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U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 10/030827	INTERNATIONAL APPLICATION NO. PCT/NO00/00236	ATTORNEY'S DOCKET NUMBER 53550.41

21. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

		CALCULATIONS	PTO USE ONLY
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO and JPO	$1040.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	$890.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$740.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	$710.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	$100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 1040.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total Claims	17 - 20 =	0	X $18.00	$	
Independent Claims	4 - 3 =	1	X **$84.00**	$ 84.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$ 280.00	
TOTAL OF ABOVE CALCULATIONS			=	$ 1,404.00	
Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2				$ 70200	
SUBTOTAL			=	$ 70200	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f))				$	
TOTAL NATIONAL FEE			=	$ 702.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property				$	
TOTAL FEES ENCLOSED =				$ 702.00	
				Amount to be refunded:	$
				charged:	$

a. ☒ A check no 6444 in the amount of $702.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 03-0678 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 03-0678. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit Card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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REGISTRATION NUMBER 22,280

EXPRESS MAIL LABEL EL680646738US

DATE: January 11, 2002

METHODS AND DEVICES FOR MEASURING INTERFACE LEVELS BETWEEN FLUIDS, AND USES THEREOF.

The present invention relates to a method and a device for measuring interface levels in separation tanks, and methods and devices for measuring concentrations/parts of a conductive fraction in flowing multi-phase mixtures, and especially where the fluids are immiscible.

The inventions have particular relation to the oil industry where immiscible phases of hydrocarbons (oil and gas) and water are being handled, as there may be present salts (give salinity to the water) in the water fraction, and greater or smaller amounts of solid particles, such as sand. The invention can be applied when one handles flowing mixtures of such fluids and wishes to know relative compositions; or in connection with separation facilities where for example oil and water are to be separated from each other.

During production of crude oil, water and gas are separated from the oil onboard the production platforms with the aid of separation tanks that function according to the principle of gravitation. The process water lies at the bottom of the tank. The next layer is an oil/water emulsion. Then comes crude oil alone, which higher up passes into foam which eventually passes into pure hydrocarbon gas. To optimise the separation process, it is necessary to be able to measure the levels of the different

layers. There are many devices for measuring the height of the different interface levels, but they all have their limitations and only a few can measure the heights of an emulsion layer and a foam layer.

It is an aim of the invention to provide a new method and device to measure the levels of the different layers in a separation tank.

Furthermore, it is an aim of the invention to provide a new method and device for measuring concentrations/parts of a conductive fraction in flowing multi-phase mixtures, and particularly where the fluids are mutual immiscible.

The method and device according to the invention is characterised by the features which become apparent from the characteristics in the respective independent claims 1 and 8, and specified embodiments become apparent from the associated dependent claims 2-7 and 9-11.

Furthermore, the methods for measuring concentrations/parts of a conductive fraction in flowing multi-phase mixtures are defined by the characteristics in the independent claims 13 and 14, while the devices are defined by the claims 15 and 16. Preferred embodiments are defined by the associated dependent claims.

According to the invention the following are applied:
1) device and method according to claims 1-11 for determination of interface layers during separation of oil-, gas- and water phases; and
2) methods and devices according to claims 12-17 for determination of the water portion in multiphase mixtures of oil, gas and water, and solid particles (sand).

The principles of the invention explained in the following description are illustrated in the subsequent figures, in which:

Figure 1 shows a set-up of the device in the form of a separation tank with the phases (from below) water, oil, and gas, and intermediate boundary layers.

Figure 2 shows a block diagram of the elements which are part of the detector according to the invention.

Figure 3 shows the measuring curve for the impedance in the coil dependent on the layer in which the measuring probe is situated.

Figure 4 shows how the invention can be used for connecting level measuring devices for measurement of levels in a container.

Figure 5 shows an assembly of an excitation and a detector coil for measuring water fraction in multiphase mixtures.

Figure 6 shows an assembly of two excitation coils and a detector coil for measuring conductive fluid (water fraction)

Figure 7 shows the results from measurements carried out on a flowing mixture of oil/water/gas by application of the device shown in figure 6.

New measuring principle

A variable magnetic field that penetrates a medium will induce eddy flows in the medium if the medium is electrically conductive or parts of it are electrically conductive. These eddy flows create a magnetic field which is directed against the imposed field. The counter-induced field will be proportional to the fraction of the conductive components in the medium and the electrical conductivity of these components.

The magnetic field can be generated by a coil to which current is supplied from an oscillator. The electrical impedance in the coil will then be dependent on the

surrounding medium. The sensitivity increases with the frequency of the magnetic field, but the frequency is limited upwards by the penetrating depth of the field into the medium.

If such a coil is placed in a separation tank, the impedance of the coil will be lowest in water and highest in gas. In foam, oil and water/oil emulsions, we will obtain values for the coil impedance in between the mentioned extreme values. In oil-, water-, and gas mixtures it is shown experimentally that the frequency between 5 MHz and 15 MHz will be an optimal compromise between increasing sensitivity and reduction in penetration depth. The frequency is determined by the diameter of the coil and number of windings. Greatest sensitivity is obtained at the resonance frequency of the coil

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

where L is the coil inductance and C is the resulting coil capacitance between the windings.

As L is inversely proportional to the counterinduced field in the medium and C is dependent on the permittivity of the medium, the resonance frequency f_o can be used to determine whether the coil is in oil, foam or gas as the capacitance C (but not the inductance L) will be different for each of these layers. Both the coil impedance and resonance frequency will be dependent on the conductivity and droplet size distribution of the conductive components (process water) at the detector coil. But it is the relative change in impedance, alternatively resonance frequency, which gives the different levels in the separation tank. The variations in the water conductivity and size distribution of water droplets in oil (oil-continuous mixture) and the size distribution of oil droplets in water (water-continuous mixture) have, therefore, no influence on the level measurements.

Figure 1 shows a diagram of the principle of the measuring set-up in the laboratory in the form of a separation tank/container 10 (typically made of glass) which contains the three phases, water, oil and gas as three separate layers in this order from below, respectively, and intermediate boundary layers. There are two emulsion layers formed between the oil phase and the water phase. The lower of these layers is a water layer 13 with a part of emulsified oil droplets which is designated a water-continuous layer, and an overlaying oil layer 15 which contains a portion of emulsified water droplets which is designated an oil-continuous layer. A measuring probe according to the invention in the form of a coil 12, and connected to an impedance analyser 17, is immersed in the container and the impedance is measured in turn in each of the above mentioned layers.

Figure 2 shows the circuitry of the detector electronics. The circuitry consists of a detector coil 20 containing a capacitance C_1 connected in parallel to a coil L_1. An amplifier 26 is retro-connected to the coil L_s and the capacitance C_1. Furthermore, the coil 20 is connected to a phase detector 22, which in turn is connected to an integrator 24, which in turn is connected to a voltage oscillator VCO.

The oscillator VCO is connected to the retro-connected circuit via a resistance R_o, and connected directly to the phase detector 22. This circuitry will ensure the excitation of the coil at resonance and make possible the measurement of the impedance of the coil and resonance frequency (at resonance the impedance is pure resistance).

Explanation of Fig. 2.
When the detector coil L_1 is in resonance with C_1, the retro-connection impedance for amplifier 26 is purely resistive and the phase displacement between ω_1 and ω_2 will be -180 degrees. In this case $\varphi_1 + \varphi_2 = 0$ and the voltage

from the phase detector 22 is zero. The integrator 24 will in this case have a constant terminal voltage which keeps the voltage-regulated oscillator at ω_2. If the detector coil's inductivity changes by the coil being surrounded by a different material, the retro-connected network for the amplifier 26 will introduce a phase displacement such that $\varphi_1 + \varphi_2$ is different from zero. The phase detector 22 supplies thereby a voltage which is integrated in the integrator 24 and the voltage-regulated oscillator changes the frequency ω_2 until L_1 and C_1 is in resonance again and thus $\varphi_1 + \varphi_2 = 0$. The frequency φ_2 will thus be characteristic for the fluid with which the detector coil is surrounded.

Results from the laboratory measurement with the probe connection according to the figures 1 and 2 are shown in figure 3. The measured coil impedance is shown as a function of level in the separation tank (N=10, f=11 MHz) (N is number of windings, f is the frequency).

From the figures 1 and 3 it will be clear that when the coil is surrounded by process water (e.g. water with conductivity 5 Siemens/meter), the coil impedance is low (ca. 10 ohms). It starts rising at ca. 5 cm because of water droplets in the oil. At 7 cm (in the water/oil emulsion layer) the impedance has risen to ca. 200 ohms to increase to 350 ohms in the oil phase.

Instead of using just one single coil which is manually moved consecutively to the mentioned layers, described above, one can use a submersible rod to which is mounted a number of such coils and which in total covers all the different layers, as shown in figure 1, as will be apparent in the next example.

<u>The practical arrangement.</u>

With reference to figure 4, a given number of coils 30a,30b,..,30h, (in this example 7 coils) are mounted on a submersible rod, immersed/placed in an enclosed tube 32 by

electrically insulating material. The coil connections in the form of wires are led through the tube 32 to an electronics box (not shown in the figure) placed on the top of the tank 34. A standard electronics multiplexer connects the coils to the detector electronics one by one and the measuring signal from the detector electronics is sent further for interpretation, presentation, information and regulation.

The measuring principle used for measuring water fraction in multiphase mixtures.

This measuring principle can also be used for measuring water fraction in multiphase mixtures in which the water component is the only electrically conductive component. In this case, an excitation coil 40 with an oscillator 41 and a detector coil 42 with a voltage detector 43, as shown in figure 5, are used. Both coils 40, 42 are fitted to the outside of a tube of electrically insulating material 44, which carries the multiphase mixture. An oscillator establishes an alternating voltage in the coil for induction of a magnetic field through the tube. The fraction (part) of electrically conductive components in the mixture determines the strength of the induced magnetic field, and thereby the induced voltage in the detector/-measuring coil.

In an oil/water/gas mixture the induced voltage in the measuring coil will be dependent on the water content, but not on the gas and oil content in the mixture, as these two components are not electrically conductive. Today in multiphase flow meters, permittivity measurement and/or gamma absorption measurement are used to determine the fractions in the mixtures. Both these measuring methods are influenced by all three components simultaneously, something which complicates the fraction estimations. The measuring principle presented here makes it possible to measure the water fraction from 0 to 100% water, independent of the amount of the other components in the mixture when these are electrically insulating. The

measurements are, however, affected by the water phase conductivity, but this influence can be eliminated by using the impedance at resonance.

The droplet size distribution in the fluid mixture will also influence the measurement result, both in water-continuous and water-discontinuous phase. To compensate for this influence, a measurement with a parallel standing excitation coil with a different resonance frequency is needed. Then we have three independent measurement variables to solve for the three unknown: Conductivity in the water component, droplet size distribution in the fluid mixture and water fraction (water cut).

<u>The practical arrangement for measuring the water fraction in fluid/gas mixtures.</u>

The measuring unit for detection of water cut in pipe flows, is for example constructed as shown in figure 6.

Two excitation coils 50, 52 are wound round an insulating tube 54 (liner) made from an electrically insulating material (such as a so-called peek). Between the two excitation coils 50, 52, a detector coil 56 for the field generated by the two outer coils, is wound round the tube 54. The three coils 50, 52, 56 are mounted inside a coat 58, typically made of steel, and the whole unit surrounds the body (tube/duct) through which the fluid is flowing. The fluid flows preferably from below and upwards, as shown with the arrow 60. The two excitation coils 50,52, are connected to the excitation coils 62 and 64, respectively, which establish respective alternating voltages with different frequencies f1 and f2, for example such that f1>f2. Furthermore, the detector coil 56 is connected to a voltage detector 66 which registers the induced alternating voltage which follows from the induced counter-flowing magnetic field which arises from the water in the flowing oil. The induced voltage in the detector coil is at any time the sum of the induced voltage from the magnetic fields from the excitation coil and thus contains two

frequencies. Amplitudes and frequencies are detected and water fraction and conductivity of the water are estimated with, e.g. the aid of mathematical models or a neural network.

If one frequency is used and the resonance frequency for one coil or induced voltage in the detector coil is used, the conductivity of the water must be known. The water fraction and conductivity can vary.

By using different frequencies one has two independent equations which can be used to estimate water fraction and the conductivity of the water by use of mentioned mathematical models.

Use of one frequency can provide both resonance frequency and impedance which gives two independent variables which also can be used to estimate water fraction and conductivity in the fluid.

The experimental results from measurements carried out on a three-component flow rig (oil/water/gas) are shown in figure 7. The figure shows the induced voltage in millivolts as a function of the water fraction in percent. It can be seen that for both the two intermediate phases, water-continuous and oil-continuous phases, the induced voltage decreases when the water fraction increases. The tests, with the measuring points given in figure 7, show the abrupt decline in induced voltage with increasing water fraction at the transition between the water-continuous and the oil-continuous phases. Exactly where the fall occurs is dependent on the direction from which the measurements are taken. Either in the oil-continuous with decreasing water fraction or in the water-continuous with increasing water fraction. Thus, a hysteresis loop is obtained, and this area defines the dividing line between the two boundary layers.

The voltage-excitation/detector coils according to the figures 5-6 are included in a larger circuit, such as the one which is used in connection with the figures 1-4, to analyse for impedance/resonance frequency, and where comparisons are made with calibrated measurement values, such that one can provide data on the content/distribution of conductive component in the multiphase fluid. Thus one can analyse for fraction of the conductive component.

The method and device which is described in connection with the figures 5-7, is particularly applicable to measuring conductive component(s) in flowing multiphase mixtures of water, oil and gas. This is relevant during exploration of hydrocarbons from an oilfield or during ordinary transport and processing of such mixtures, for example in refineries.

Such flowing mixtures are more or less mixed to emulsions, e.g. oil droplets in water (water-continuous phase) or water droplets in oil (oil-continuous phase), i.e. on a scale between pure water phase and pure oil phase. Over time, the condition in such a mixture will vary.

This means that the method and device, in combination with the use of hysteresis curve presentation as shown in figure 7, can be used to find out (with the aid of data processing with mathematical models or neural networks) which type of emulsion that is dominant in the flowing fluid at any time, and where on the mentioned scale the emulsion is lying (in droplets size distribution). Thus, one can all the time monitor and provide information about the condition in the multiphase flow. This is a very important application of the invention, and represents a large step forward for the oil industry.

Corresponding methodology is applied to mapping of any occurring transition-emulsions between pure oil and water phases in a tank, such as in a storage tank, as described in connection with the figures 1-4. Thus, one can map

where the transition between oil-continuous and water-continuous phase is lying.

In addition, the invention may be applied to all multiphase mixtures (particularly immiscible mixtures), which contain a mixture of conductive and non-conductive components. For example, generally within the chemical industry, and the food industry, such as during handling of milk, for example during homogenisation where the fraction/part of fat in the milk shall be regulated and emulsified.

CLAIMS

1. Method for measuring interphase levels between fluids, characterised in that

a variable magnetic field is established in one of the fluids by means of a device creating a magnetic field, whereby a counter-flowing magnetic field is established, being a function of the properties of the fluid with respect to the portion of conductive fraction in the fluid, and the conductivity of the fraction;

and the properties of the mentioned fluid are registered by registering of the system's prominent impedance, alternatively a resonance frequency, and

by corresponding registration in different fluid layers at various height levels, and in the existing interphase layers, and thereafter mutual comparison of mentioned properties, one or more interphase levels that are present are determined.

2. Method in accordance with claims 1-2, characterised in that the magnetic field creating means comprises a coil which receives an alternating voltage, such as by means of an oscillator.

3. Method in accordance with claims 1-2, characterised in that a number of mutually separate coils (30a,30b,..,30h) are being used, arranged in a tube (32) of electrically insulating material, with said tube being arranged in the fluid mixture, the level ratio of which is to be registered, and the coils are connected one by one to an impedance analyser/detector electronics via a multiplexer, for further treatment of the measured data.

4. Method in accordance with one of the claims 2-3, characterised in that the resulting impedance/resonance frequency (17) is registered from the established counter-induced voltage (magnetic field), depending on which fluid (boundary layer) the respective coil is in contact with.

5. Method in accordance with one of the preceding claims characterised in using a connection is provides for excitation of the coil(s) at resonance including measurement of the coil(s) impedance, comprising:

a detector coil (20) comprising a capacitance C_1 connected in parallel with a coil L_1, an amplifier (26) which is retro-connected to the coil L_s and capacitance C_1, and the coil (20) is connected to a phase detector (22), which in turn is connected to an integrator (24) and further to a voltage oscillator VCO,

and said oscillator VCO being connected to the retro-connection circuit via a resistance R_o, and connected directly to the phase detector (22),

such that excitation of the coil is ensured at resonance, and the coil impedance and resonance frequency can be measured, as the impedance is pure resistance at resonance.

6. Method in accordance with one of the preceding claims, characterised in that measurements are carried out at frequencies up to 20 MHz, particularly in the range 5-15 MHz.

7. Method in accordance with claim 3, characterised in that the coil resonance frequency

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

for the different fluid phases is measured, with L being the coil inductance and C the resulting capacitance between the windings.

8. Device for measuring interphase levels between fluids, characterised by one or more means for establishing magnetic field is/are arranged in order to establish a variable magnetic field in the fluids, and

means for registering (17) of the impedance/resonance frequency resulting from the counterinduced voltage

(magnetic field) formed, which depends on which fluid (boundary layer) the respective magnetic field establishing means is in contact with.

9. Device in accordance with claim 8, characterised in that the magnetic field forming means comprises a coil which can receive an alternating voltage, such as by means of an oscillator.

10. Device in accordance with claim 9, characterised in that a number of coils (30a,30b,…,30h) are arranged inside a tube of electrically insulating material, with the coil connections being fed to a junction unit which is arranged to connect the coils to the detector electronics one by one, such as an impedance analyser, and the measuring signal from the detector electronics is sent further for interpretation, presentation, information and regulation.

11. Device in accordance with claim 10, characterised by a detector connection comprising:

a detector coil (20) comprising a capacitance C_1 connected in parallel with a coil L_1, an amplifier (26) which is retro-connected to the coil L_s and the capacitance C_1, and the coil (20) is connected to a phase detector (22), which in turn is connected to an integrator (24) and further to a voltage oscillator VCO,

said oscillator VCO being connected to the retro-connection circuit via a resistor R_o, and connected directly to the phase detector (22).

12. Method for measuring concentrations/parts of a conductive fraction in flowing multiphase mixtures, characterised in that

an excitation coil (40) and a detector coil (42) are arranged enclosingly around a body, such as a tube (44), which carries the multiphase volume; the excitation coil (40) is applied an alternating voltage, and the resulting detector voltage registered in the detector coil (44) is compared to calibration values of the system to determine

the part of conductive fractions in the multiphase flow/volume.

13. Method for measuring concentrations/parts of a conductive fraction in flowing multiphase mixtures, <u>characterised in that</u>

the parameters in the form of the conductivity of the conducting fraction, size distribution of droplets in the fluid mixture and conductive fractions are measured by application of two excitation coils (55, 57) with respective mutually different resonance frequencies f_1 and f_2, and a detector coil (56), and the induced voltage in the detector coil (56), which is the sum of the induced voltage from the magnetic fields from the two excitation coils (55, 57), and comprising two frequencies, is applied to estimate the independent parameters, such as by means of mathematical models or neural networks.

14. Method in accordance with claims 12-13, <u>characterised in that</u> the method is applied to a flowing mixture of oil, water and gas, where the water is electrically conductive, while the gas and the oil are not conductive.

15. Device for measuring concentrations/parts of a first fluid in a second fluid in multiphase mixtures, or in flows of the fluids, <u>characterised in that</u>

an excitation coil and a detector coil are arranged enclosingly round the volume (such as a pipe which carries the multiphase fluid), in that the excitation coil is arranged to be applied an alternating voltage, and a resulting detector voltage is arranged to be registered, and the detector voltage is compared to calibration values of the system to determine the portion of conductive fraction in the multiphase stream/volume.

16. Device for measuring concentrations/parts of a first fluid in a second fluid in multiphase mixtures, or in flows of the fluids, <u>characterised in that</u>

two excitation coils (55, 57) which, via excitation oscillators (62, 64) respectively, are arranged to be driven by mutually different resonance frequencies f_1 and f_2 respectively; and a detector coil (56) connected to a voltage detector, with the excitation coils (55, 57) and the detector coil (56) being arranged enclsoingly around the volume (such as a tube that carries the multiphase fluid forward).

17. Device in accordance with claim 16, <u>characterised in that</u> the detector coil (56) is arranged between the two excitation coils (50, 52), and that the unit of the three coils (50, 52, 56) is mounted inside a coat (58), typically made from steel, and the unit surrounds the means (tube/duct) through which the fluid is flowing.

18. Application of
1) device and method according to claims 1-11 for determination of interphase layers during separation of oil, gas and water phases; and of
2) methods and devices according to claims 12-17 for determination of the part of water in multiphase mixtures of oil, gas and water and solid particles (sand).

19. Application in accordance with claim 18 for measuring/registering of interphase layers which comprise an oil-continuous layer with a droplet size distribution of water in the oil, and a water-continuous layer with a droplet size distribution of oil in the water, and where the boundary layer between the oil phase and the gas phase comprises a foam layer.

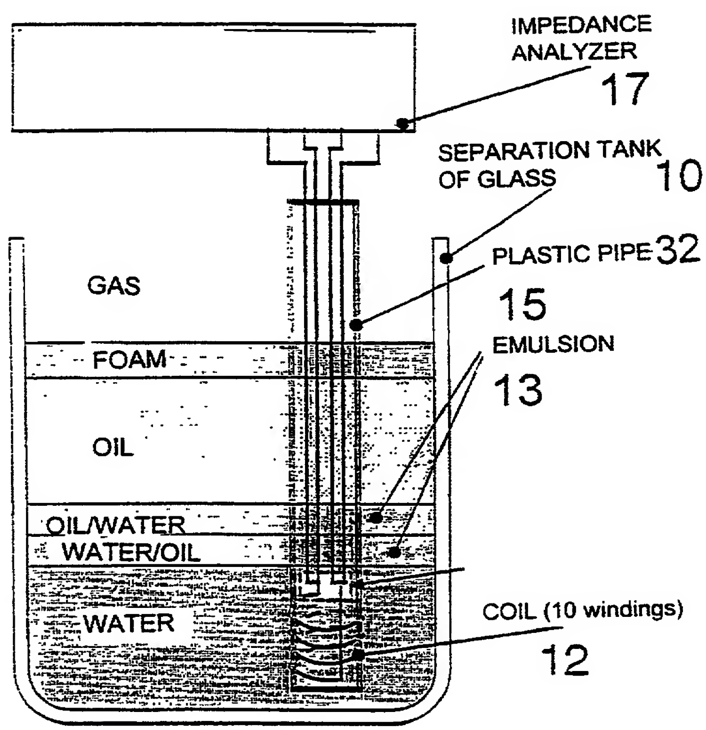

FIG 1
FLOW CHART OF THE MEASURING SET UP IN LABORATORY.

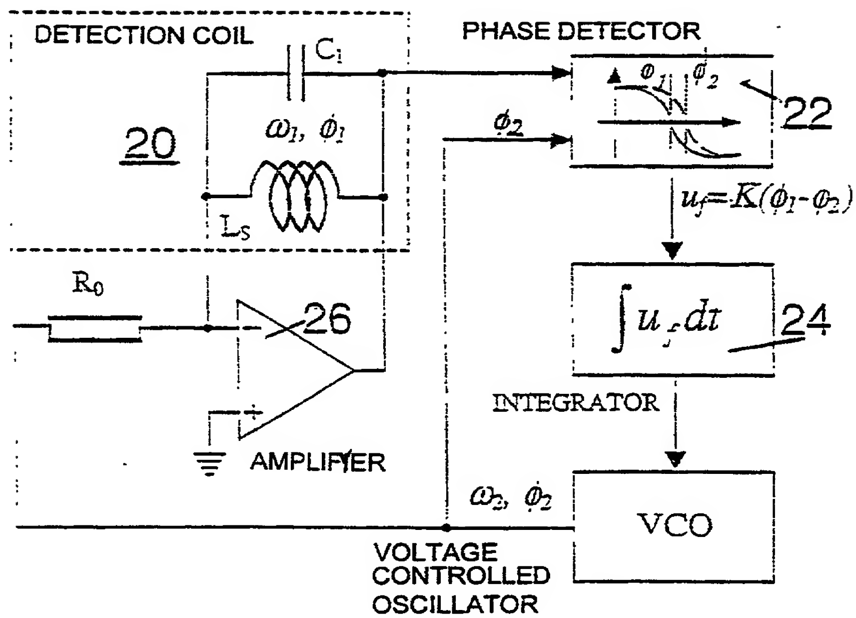

FIG 2

BLOCK DIAGRAM OF DETECTOR ELECTRONICS

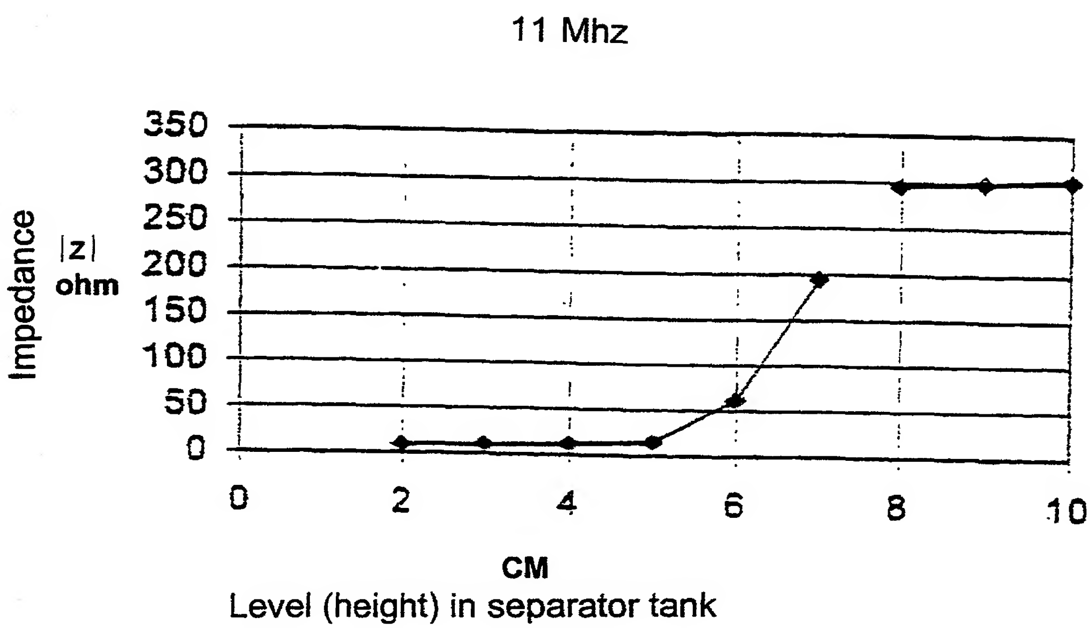

FIG 3
COIL IMPEDANCE AS A FUNCTION OF LEVEL IN SEPARTOR TANK
(N=10, f=11 MHz)

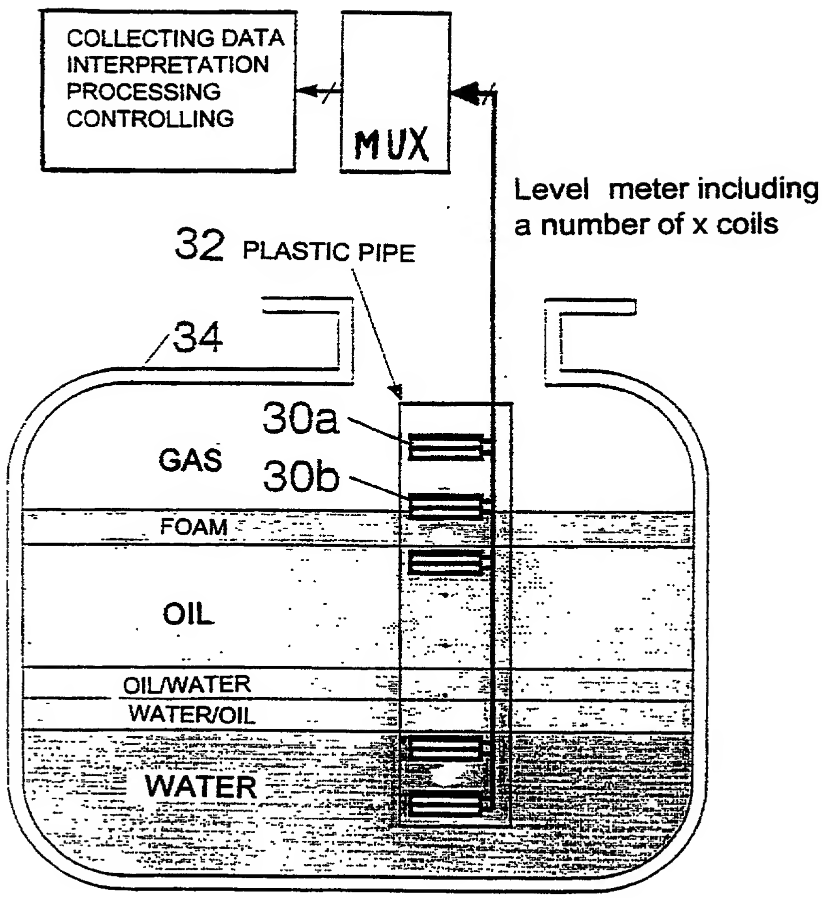

FIG 4

FLOW CHART OF EQUIPMENT FOR LEVEL MEASURING.

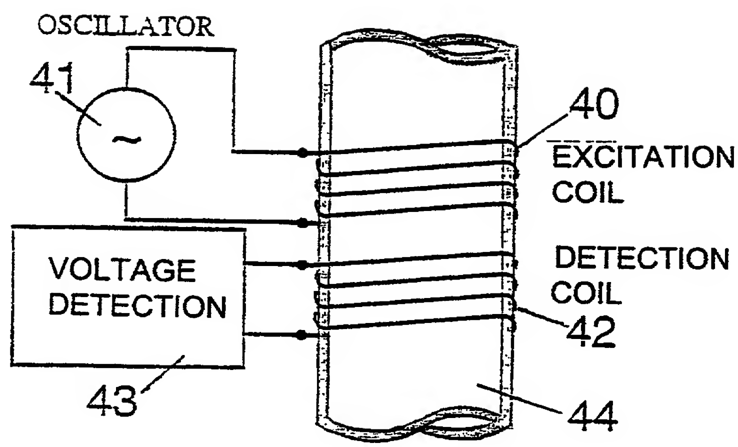

FIG 5

PRINCIPLE FOR METERING
WATER CUT IN MULTIPHASE MIXTURES.

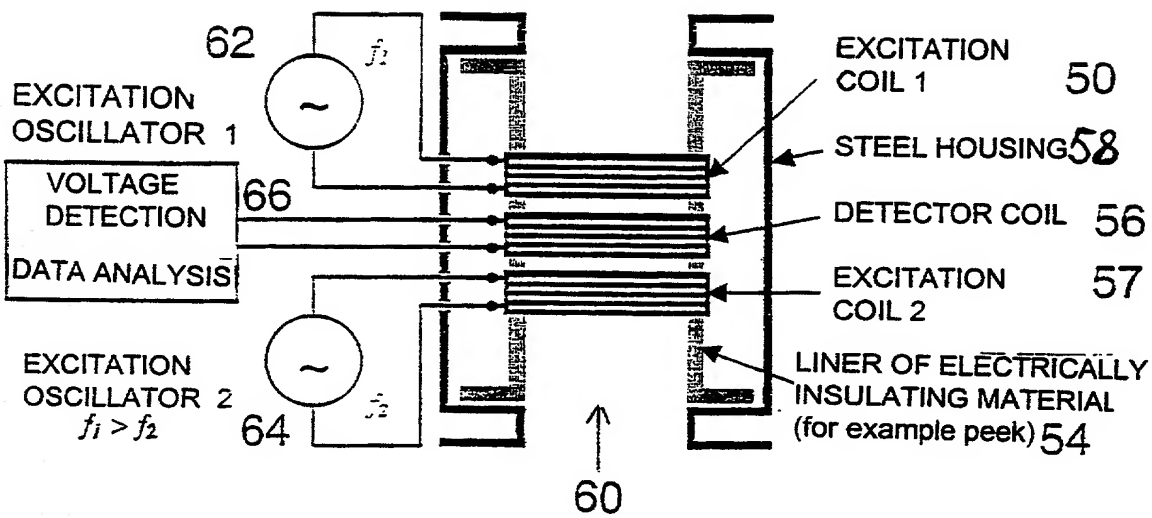
62
f_1
EXCITATION
OSCILLATOR 1
VOLTAGE
DETECTION
DATA ANALYSIS
66
EXCITATION
OSCILLATOR 2
$f_1 > f_2$
64
f_2
EXCITATION
COIL 1
50
STEEL HOUSING
58
DETECTOR COIL
56
EXCITATION
COIL 2
57
LINER OF ELECTRICALLY
INSULATING MATERIAL
(for example peek)
54
60

FIG 6

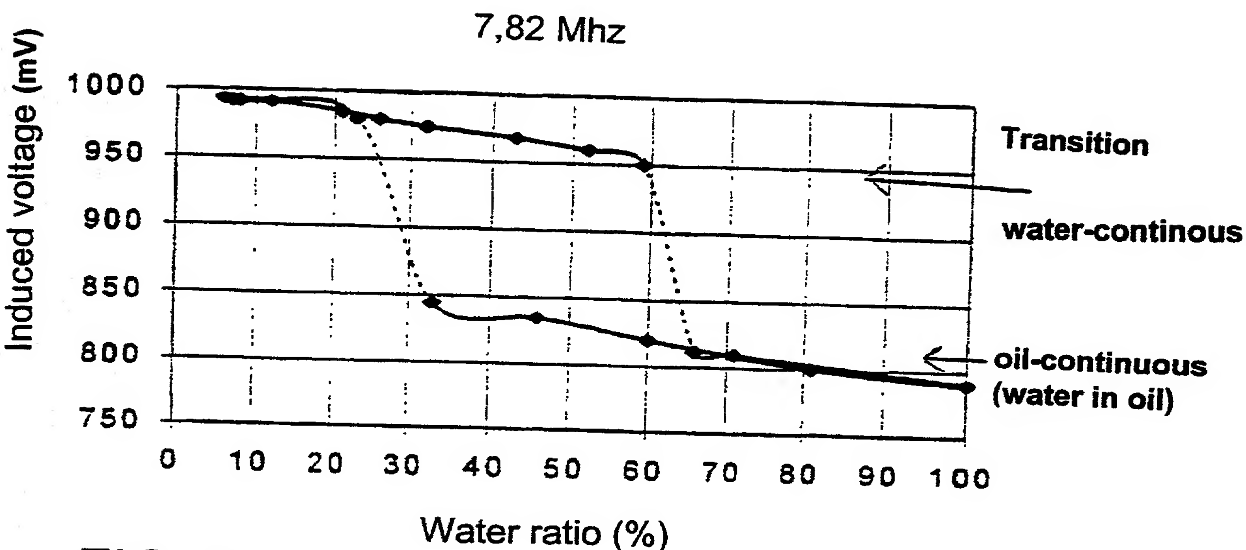

FIG 7
RESULTS OF MEASUREMENTS FROM
A THREE-PHASE FLOW RIG OF OIL/WATER/GAS.

Please type a plus sign (+) inside this box → [+]

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing *OR* ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	53550.41
First Named Inventor	Erling Hammer
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named Inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

METHODS AND DEVICES FOR MEASURING INTERFACE LEVELS BETWEEN FLUIDS AND USES THEREOF

the specification of which

☐ is attached hereto

OR

☒ was filed on 11 July 2000 as United States Application Number or PCT International Application Number PCT/NO00/00236 and was amended on (mm/dd/yyyy) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
PCT/NO00/00236	WIPO	11July 2000	☐	☐	☐
19993436	Norway	12 July 1999	☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION ---- Utility or Design Patent Application

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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City		State	ZIP	Country	

NAME OF SECOND INVENTOR: ☐ A petition has been filed for this unsigned inventor.

Given Name (first and middle [if any])			Family Name or Surname		
Inventor's Signature				Date	
Residence: City		State	Country	Citizenship	
Mailing Address					
Mailing Address					
City		State	ZIP	Country	

☐ Additional inventors are being named on the _____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

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